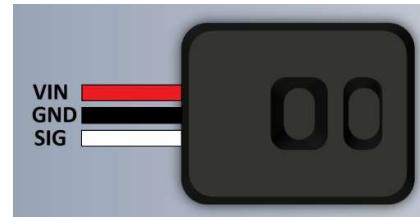


TOF Distance sensor

Device pinout

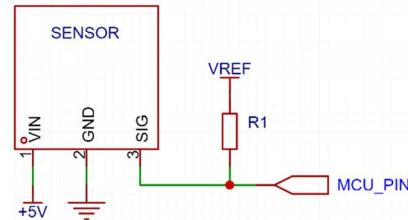
| | |
|-----|--|
| VIN | Connect to power supply |
| GND | Connect to main ground |
| SIG | Sensor communication open-drain input / output |



Typical application

The sensor can operate from 2.8V to 5.5V, ensure that the power supply can handle up to 30mA.

The SIG pin is open drain, so for correct operation a pull-up resistor must be placed, typically between 2.4k and 10k, lower resistance means higher power loss but is needed for higher serial speed. The voltage of the pull-up resistor should be $\geq 2.8V$, typically just connect it to the same supply as the MCU uses.



Electrical characteristics

| Parameter | Conditions | Min | Typical | Max | Unit |
|-------------------------|------------|------|---------|-----|------|
| Maximum allowed voltage | | -0.3 | | 7 | V |
| Operating voltage | At 25°C | 2.8 | 5 | 5.5 | V |
| Supply current | | | 25 | 30 | mA |

Sensor characteristics

| Parameter | Conditions | Min | Typical | Max | Unit |
|-------------------------|-----------------------|-----|---------|-----|------|
| Sampling delay | | | | | |
| Maximum range | Sampling time is 50ms | | 1200 | | mm |
| Wavelength | | | 940 | | nm |
| Detection field of view | | 18 | | 22 | ° |
| Start-up time | | 10 | | 50 | ms |

Device operation

As soon as the sensor starts (see Start-up time), measurement begins and data can be read. The sensor can be used to measure distance in millimetres or centimetres. Sensor can also be configured to detect some range condition, i.e. if distance is above some threshold.

Depending on the I/O configuration the sensor outputs either a digital 0/1, PWM or serial, these function in the following ways:

Serial

Half duplex UART, used to read sensor registers and change configuration.

Digital 0/1

In this mode the SIG pin outputs the detection state, LOW if false, HIGH when true. Detection mode and threshold can be configured.

PWM

SIG pin outputs a PWM signal, the wave form is the same as in servo control. The period is 20ms, the pulse is 1ms – 2ms. The pulse width changes with the measured distance, 1ms = minimum distance, 2ms = maximum distance, max and min can be configured. If the distance measurement is invalid, then the pulse will be 2ms.

Device configuration

When the device is in serial mode all sensor parameters can be changed, the new values are immediately used, except for the I/O configuration these only apply after the sensor is restarted. After reset the configuration registers are set from the sensor's internal memory, configuration registers can be saved to this memory using the "save configuration" command. To restore configuration back to default, "reset configuration" command can be used.

Device restart

The sensor can be restarted either by disconnecting and reconnecting the power supply or using the "restart sensor" command.

Entering serial mode

If the sensor is configured in digital or PWM mode, to change to serial simply disconnect the power supply, then short the SIG pin to GND or alternatively output a LOW signal from MCU, afterwards connect the power supply and wait at least 50ms for the sensor to boot, then remove the short from SIG. The sensor will now be in serial mode with 9600 baud rate and id 0. When the sensor is reset, the mode will return to the one configured in registers.

Serial protocol

The serial protocol uses ASCII characters; numbers are in hexadecimal format. Each packet starts with the command letter and ends with a new line symbol 0x0A, or '\n' in most programming languages; the following commands are available:

Write register

| | | | | | |
|---------|--------|-------------|-------------------|---------|------------|
| Send | W | 'serial id' | 'register number' | 'value' | '\n' (0xA) |
| Receive | A or F | '\n' (0xA) | | | |

Serial id is sent in hexadecimal format as two characters, the same for the register number. Value is also in hexadecimal format but can be of variable length up to 4 characters, for example if the value is 0x0005, then you can send 5 or 0005, the leading zeroes are not mandatory. After the command is received the sensor returns A if the write was successful and F if it failed.

Examples of messages written as C strings:

Set register B0 of sensor 01 to 21:

Send -> "W01B021\n"

Receive <- "A\n" (success)

Set register 00 of sensor 00 to F65:

Send -> "W0000F65\n"

Receive <- "F\n" (Failure because register 00 is read only)

Read register

| | | | | |
|---------|------------------|-------------|-------------------|------------|
| Send | R | 'serial id' | 'register number' | '\n' (0xA) |
| Receive | 'register value' | '\n' (0xA) | | |

The returned register value is in hexadecimal format and is of variable length up to 4 characters, example if the value is 0x0080, the returned value will be 80.

Example of message:

Read register 01(distance mm) of sensor A6:

Send -> "RA601\n"

Receive <- "12C\n" (distance 0x12C = 300 mm)

Save configuration

| | | | |
|---------|---|-------------|------------|
| Send | S | 'serial id' | '\n' (0xA) |
| Receive | A | '\n' (0xA) | |

This command saves the current configuration to the sensor memory.

Restart sensor

| | | | |
|---------|---|-------------|------------|
| Send | U | 'serial id' | '\n' (0xA) |
| Receive | A | '\n' (0xA) | |

This command restarts the sensor; the reset is executed ~50ms after the sensor sends its response. After reset all registers are set to the saved configuration.

Reset configuration

| | | | |
|---------|---|-------------|------------|
| Send | Z | 'serial id' | '\n' (0xA) |
| Receive | A | '\n' (0xA) | |

This command resets the sensors configuration back to the default settings.

Registers

Read-only registers:

| index | Name | Min value | Max value |
|---|------------------|-----------|-----------|
| 00 | Ranging status | 0 | FF |
| Status of measurement. | | | |
| Bit 0 – Measurement is valid. Bit 1 – Range wraparound check not passed. Bit 2 – Range phase check not passed. Bit 3 – Signal minimum check not passed. Bit 4 – Signal threshold check not passed. Bit 5 – Sigma threshold check not passed. Bit 6 – Distance min check not passed. Bit 7 – Distance max check not passed. | | | |
| 01 | Distance mm | 0 | FFF |
| Measured distance in millimeters. If the measured distance is invalid the value will be FFF. | | | |
| 02 | Signal rate | 0 | FFFF |
| Amount of signal returned in last measurement. | | | |
| 03 | Ambient rate | 0 | FFFF |
| Amount of ambient light in last measurement. | | | |
| 04 | Sigma | 0 | FFFF |
| Measurement standard deviation in mm. | | | |
| 05 | SPAD count | 0 | FFFF |
| Number of photon detectors used in last measurement. | | | |
| 06 | Distance cm | 0 | FF |
| Measured distance in centimeters. If the measured distance is invalid the value will be FF. | | | |
| 07 | Detection output | 0 | 1 |
| The output of detection logic configured in register BA. | | | |

Configuration registers:

| Index | Name | Min | Max | Default |
|--|----------------------|-----|------|---------|
| 80 | IO mode | 0 | 2 | 1 |
| IO mode selection, when changed the new value will take effect after sensor restart. | | | | |
| Modes: 0 – Serial. 1 – Digital 0/1. 2 – PWM. | | | | |
| 81 | Serial id | 0 | FF | 0 |
| Serial id when IO mode is 0. | | | | |
| B0 | Serial baud | 0 | 7 | 0 |
| Serial baud rates: 0 – 9600. 1 – 19200. 2 – 38400. 3 – 57600. 4 – 74880. 5 – 115200. 6 – 230400. 7 – 250000. | | | | |
| 83 | | | | |
| 84 | | | | |
| B0 | Sampling time ms | 5 | 50 | 33 |
| Sensor sampling time in milliseconds. Operation below 10ms is not guaranteed. | | | | |
| B1 | Offset correction | 0 | FFFF | 0 |
| Measurement offset correction value. | | | | |
| B2 | Crosstalk correction | 0 | FFFF | 0 |
| Measurement crosstalk correction value. | | | | |
| B3 | Linear correction | 0 | FFFF | 8000 |
| Linear correction factor, the distance mm is calculated: $D = \text{Draw} * \text{correction} / 0x8000$ | | | | |

| | | | | |
|---|------------------------------|---|------|-----|
| B4 | Range checks | 0 | FF | F8 |
| Various checks are performed to determine if the measurement is valid, each bit in this register corresponds to one checked condition. If a measurement passes all enabled checks, it is considered valid. All checks are always performed, and their status is written to register 0, but only those that are enabled here are used to determine validity. | | | | |
| Bit 0 – Not used. Bit 1 – Range wraparound check. Bit 2 – Range phase check. Bit 3 – Signal minimum check. Bit 4 – Signal threshold check. Bit 5 – Sigma threshold check. Bit 6 – Distance min check. Bit 7 – Distance max check. | | | | |
| B5 Signal threshold | | | | |
| Minimum amount of photons to consider a valid distance. If measured signal is below this threshold Signal threshold check is not passed. | | | | |
| B6 | Sigma threshold | 0 | FFFF | 15 |
| Standard deviation threshold in mm, if measured sigma is above this threshold Sigma threshold check is not passed. | | | | |
| B7 | Min distance mm | 0 | FFF | 1 |
| Minimum detection distance, if bit 6 in register B4 is 1, then any distance below minimum will be considered invalid. | | | | |
| B8 | Max distance mm | 0 | FFF | 500 |
| Maximum detection distance, if bit 7 in register B4 is 1, then any distance above maximum will be considered invalid. | | | | |
| BA | Detection mode | 0 | 2 | 0 |
| Selects detection mode, depending on this register, the detection output value will be 1 when: 0 – Measurement is valid (status register bit 0 is 1). 1 – Distance mm is above lower threshold, register BC. 2 – Distance mm is above lower threshold and below upper threshold registers BC and BD. | | | | |
| BB | Detection output invert | 0 | 1 | 0 |
| 0 – Detection output normal. 1 – Detection output inverted. | | | | |
| BC | Detection lower threshold mm | 0 | FFF | 0 |
| Detection lower threshold, for detection modes 1 and 2. | | | | |
| BD | Detection upper threshold mm | 0 | FFF | 0 |
| Detection upper threshold, for detection modes 1 and 2. | | | | |